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A Ponderosa Pine-Grand Fir Spacing Study in Central Oregon: Results After 10 Years

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Abstract

The 10-year growth response from an initial spacing study established in a ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.) plantation was measured in central Oregon. The study was designed to compare the growth rates of pure pine, pure fir, and a 50-percent mixture of each species planted at 6-, 12-, and 18-foot spacings. Height growth of pure pine was about twice as great as that of pure fir because of damage to the fir from frost and animals; growth of the pine-fir mixture was intermediate. Both basal area and total cubic volume increment per acre increased at the narrower spacing but diameter growth per tree was less. The height advantage of the pine is likely to be maintained in the future.

Keywords: Stand density, plantation spacing (-growth, increment, ponderosa pine, grand fir, central Oregon, Oregon (central).

Introduction

Spacing and thinning studies distributed over a range of sites, stand ages, and species provide information on the growth response of managed stands that enables the forest manager to select tree spacing or to design thinning schedules to meet land management objectives. Such information is also useful in developing and verifying long-term growth and yield models of managed stands. Considerable information is available on the growth response of pure, even-aged stands of many species to various density regimes, but little is known about the response of mixed species stands.

In 1974, a spacing study was begun in a plantation established with seedlings of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.) in central Oregon. The purpose was to obtain information on the productivity of pure and mixed stands of these species at several spacings in terms of diameter, height, basal area, and volume growth. This paper reports results from the first 10 years of the study or two 5-year growth periods (1975-79 and 1980-84). Results are strictly applicable only to the plant community in which the study is located but should be generally useful in similar mixed conifer communities of comparable site quality on the east slopes of the Cascade Range in Oregon from Bend to Klamath Falls.

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Study Area and Methods

The study is located in the Lookout Mountain unit of the Pringle Falls Experimental Forest in the Deschutes National Forest about 35 miles southwest of Bend, Oregon. The study is on a north-facing, 20-percent slope at an elevation of about 5,100 feet. The soil is a well-drained Typic Cryorthent (Shukash series) developed in dacite pumice originating from the eruption of Mount Mazama about 6,500 years ago. It has an Al, AC, C1, C2 pumice horizon about 3 feet deep over the buried soil.

The study area is a 20-acre clearcut in a mixed conifer/snowbrush-chinkapin plant community (Volland 1982). Typical ground cover in this community consists primarily of snowbrush (*Ceanothus velutinus* Dougl. ex Hook.), greenleaf manzanita (*Arctostaphylos patula* Greene), and golden chinkapin (*Castonopsis chrysophylla* (Dougl.) A. DC.). Site index of mature ponderosa pine in the area is about 90 feet at age 100 (Meyer 1961).

Three initial spacings (6 by 6, 12 by 12, and 18 by 18 feet) and three species combinations (pure pine, pure fir, and 50 percent of each species) were tested in a completely randomized split-split plot design. Whole plot treatments were spacings, split-plot treatments were species combinations, and time periods were the split-split plot factor. Each spacing was replicated three times for a total of nine whole plots, and each whole plot was split into three subplots to result in 27 subplots (fig. 1). The 50-percent pine-fir subplots were planted by alternating pine and fir seedlings within each row. Twenty-four trees were measured in the interior of each plot; plot size, including buffer strips, ranged from 0.1 acre to 0.54 acre, depending on spacing. No thinning is planned for these plots in the future.

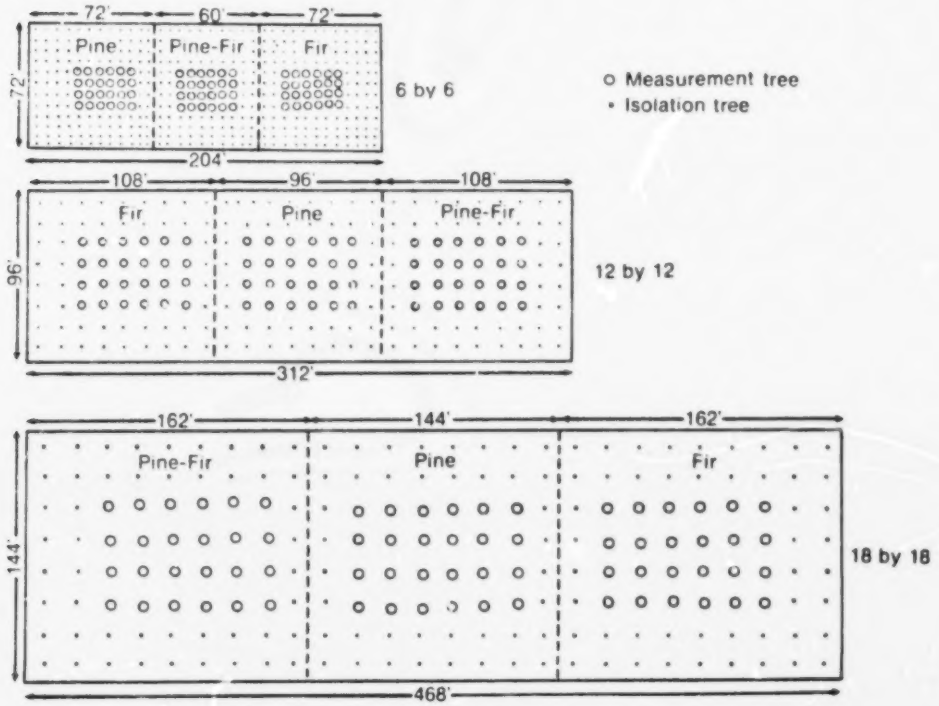

Figure 1.—One replication of spacing plots showing random assignment of the species combination split plots within each whole plot.

Planted seedlings were 2-0 bare root ponderosa pine grown in the USDA Forest Service nursery in Bend and 2-year-old containerized grand fir grown in a greenhouse in 1-quart milk cartons. Seed of both species was collected near the study area in 1971. Seedlings were planted with an auger from May 27 to June 7, 1974. The entire carton was removed from around the fir seedlings just before planting leaving the root ball intact. Fir seedlings were thinned to two per carton before planting and two pine seedlings were planted at each spot. Both fir and pine seedlings were thinned to one per spot at the end of the third growing season. Extra seedlings of both species were planted near the plots and used to replace those in the plots that died during the first 2 years. Snowbrush, manzanita, and chinkapin within the study area were sprayed with herbicide in June 1976 and June 1979 to eliminate competition from these species.

Total height of all plot trees was measured to the nearest 0.1 foot, in spring 1975 and autumn 1979 and 1984. Diameter at breast height (d.b.h.) of trees 0.6 inch or larger was measured to the nearest 0.05 inch in 1979 and 1984. An equation expressing total cubic volume inside bark as a function of diameter^2 x height (D^2H) was constructed for each species and used for volume estimation in 1979 and 1984. Remeasurement of this study is planned at 5-year intervals with publication of the latest results every 10 years.

Split-plot analyses of variance were used to compare spacings, species mix, and growth periods for height, basal area, and volume growth. Tukey's test was used to determine significant differences among treatment means.

Characteristics of the plots after planting and in 1979 (age 7) and 1984 (age 12) are given in table 1. Average height of the planted pine was only slightly greater (0.6 foot) than that of the fir (0.4 foot); after 10 years, average diameter of measurable trees at each spacing was about 2 inches.

Results

Mortality and Damage

Survival of both pine and fir seedlings was excellent. Only 2 percent of the pine and 1 percent of the fir seedlings died during the first 2 years after planting. Of the 324 seedlings (measurement trees) of each species present at the end of the third growing season, one pine seedling died before the 1979 remeasurement and six fir seedlings died during the second 5-year period (1980-84).

Fir seedlings were damaged by birds eating terminal buds during 1976 and by freezing temperatures killing new growth in spring 1979. This resulted in slower height growth of many seedlings. These results are not surprising because previous studies have shown white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.) to be considerably less frost tolerant than ponderosa pine in clearcut areas (Fowells and Stark 1965, Schubert 1956). A few fir were also damaged by deer rubbing their antlers on terminal shoots. Pine seedlings were undamaged except for some snow breakage on a few seedlings during one winter.

Table 1—Characteristics of ponderosa pine-grand fir plots and subplots in 1975, 1979, and 1984

Year, spacing, and species composition	Trees per acre	Trees per acre 0.6-inch d.b.h. or larger		Quadratic mean diameter 1/	Average height 2/	Basal area 1/	Total volume 1/
			percent	inches	feet	ft^2/acre	ft^3/acre
1975 (age 2):							
6 by 6 feet--							
Pure pine	1,200	--	--	--	0.7	--	--
Pure fir	1,200	--	--	--	.4	--	--
Pine-fir	1,200	--	--	--	.6	--	--
Mean	1,200				.6		
12 by 12 feet--							
Pure pine	304	--	--	--	.6	--	--
Pure fir	304	--	--	--	.5	--	--
Pine-fir	304	--	--	--	.5	--	--
Mean	304				.6		
18 by 18 feet--							
Pure pine	134	--	--	--	.6	--	--
Pure fir	134	--	--	--	.4	--	--
Pine-fir	134	--	--	--	.6	--	--
Mean	134				.5		
1979 (age 7):							
6 by 6 feet--							
Pure pine	1,200	183	15	0.7	3.8	0.50	8.2
Pure fir	1,200	--	--	--	2.1	--	--
Pine-fir	1,200	117	10	.7	2.9	.40	5.7
Mean	1,200	100	8	.7	2.9	.30	4.6
12 by 12 feet--							
Pure pine	300	17	6	.8	3.5	.06	1.0
Pure fir	304	--	--	--	2.3	--	--
Pine-fir	304	13	4	.7	3.0	.04	.6
Mean	303	10	3	.7	2.9	.03	.5
18 by 18 feet--							
Pure pine	134	11	8	.9	3.6	.06	.6
Pure fir	134	--	--	--	2.2	--	--
Pine-fir	134	--	--	--	2.8	--	--
Mean	134	4	3	.9	2.9	.02	.2
1984 (age 12):							
6 by 6 feet--							
Pure pine	1,200	1,150	96	2.3	9.7	32.6	205.7
Pure fir	1,183	283	24	1.0	5.2	2.4	17.5
Pine-fir	1,200	867	72	2.3	8.3	24.6	156.8
Mean	1,194	767	64	1.9	7.7	19.9	126.7
12 by 12 feet--							
Pure pine	300	295	98	2.7	10.3	11.8	71.9
Pure fir	296	207	70	1.2	6.8	1.7	11.7
Pine-fir	295	249	85	2.3	8.8	7.6	46.9
Mean	297	250	84	2.1	8.6	7.0	43.5
18 by 18 feet--							
Pure pine	134	134	100	3.0	10.5	6.6	37.6
Pure fir	134	60	45	1.0	5.7	.3	2.3
Pine-fir	132	99	75	2.7	8.4	3.9	22.6
Mean	133	98	73	2.2	8.2	3.6	20.8

1/ All trees 0.6 inch d.b.h. and larger.
2/ All trees.

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Table 2—Periodic annual increment of a ponderosa pine and grand fir plantation during two 5-year measurement periods from 1975 to 1984.

Measurement period and spacing	Diameter growth 1/				Height growth				Gross basal area growth 2/				Gross total volume growth 2/			
	Pine	Fir	Pine-fir	Mean	Pine	Fir	Pine-fir	Mean	Pine	Fir	Pine-fir	Mean	Pine	Fir	Pine-fir	Mean
	inches				feet				ft^2/acre				ft^3/acre			
1975-79 (age 2 to 7):																
6 by 6 feet	--	--	--	--	0.6	0.4	0.6	0.5	0.10	--	0.08	0.06	1.6	--	1.1	0.9
12 by 12 feet	--	--	--	--	.6	.3	.5	.5	.01	--	.01	.01	.2	--	.1	.1
18 by 18 feet	--	--	--	--	.6	.4	.4	.5	.01	--	--	.003	.1	--	--	.03
1980-84 (age 7 to 12):																
6 by 6 feet	0.50	--	0.50	0.50	1.2	.6	1.0	.9	6.5	.5	4.8	3.9	39.5	3.5	30.2	24.4
12 by 12 feet	.61	--	.64	.62	1.4	.9	1.2	1.2	2.4	.3	1.5	1.4	14.2	2.3	9.2	8.6
18 by 18 feet	.68	--	--	.68	1.4	.7	1.1	1.1	1.3	.7	.8	.7	7.4	.5	4.5	4.1

1/ Arithmetic mean diameter growth of trees 0.6 inch d.b.h. or larger at beginning of 5-year period and living through the period. Based on growth of 31 pine seedlings.
2/ Includes ingrowth.

Diameter Growth

Diameter growth data are limited for these first two growth periods because none of the fir seedlings had reached 0.6-inch d.b.h. by 1979, and only about 10 percent of the pine seedlings had attained this size. Growth of these 31 trees was excellent, however, and ranged from an average of 0.5 inch per year at the 6-foot spacing to 0.68 inch annually at the 18-foot spacing during the second 5-year period (table 2). No statistical comparisons were made for diameter growth because too few trees existed per experimental unit.

Height Growth

The most rapid rate of height growth (1.4 feet per year) was found on pure pine at the 12- and 18-foot spacings during the second period; the slowest growth rate (0.3 to 0.4 foot per year) was measured on pure fir during the first period (table 2, fig. 2). Significant differences ($P < 0.01$) in height growth were found among spacings, species combinations, and growth periods. Height growth during the second period was twice that of the first period (0.5 vs. 1.1 foot per year) when averaged over all spacings and species combinations (table 2). All three species combinations were significantly different from each other with height growth averaging 1.0 foot per year for the pure pine, 0.8 foot for the pine-fir mixture, and 0.6 foot for the pure fir. Growth of fir was considerably less than that of pine during the second period because of the freezing and animal damage sustained by the fir. Although average height growth differences between pine and fir were not large on an annual basis, after 10 years this difference in growth rates resulted in pine being almost twice as tall as fir (10.2 vs. 5.9 feet) (table 1).

Growth differences among spacings were not as large as those among species combinations. Height growth at the 6-foot spacing was significantly less than at the 12- or 18-foot spacing but no significant differences were found between the 12- and 18-foot spacings.

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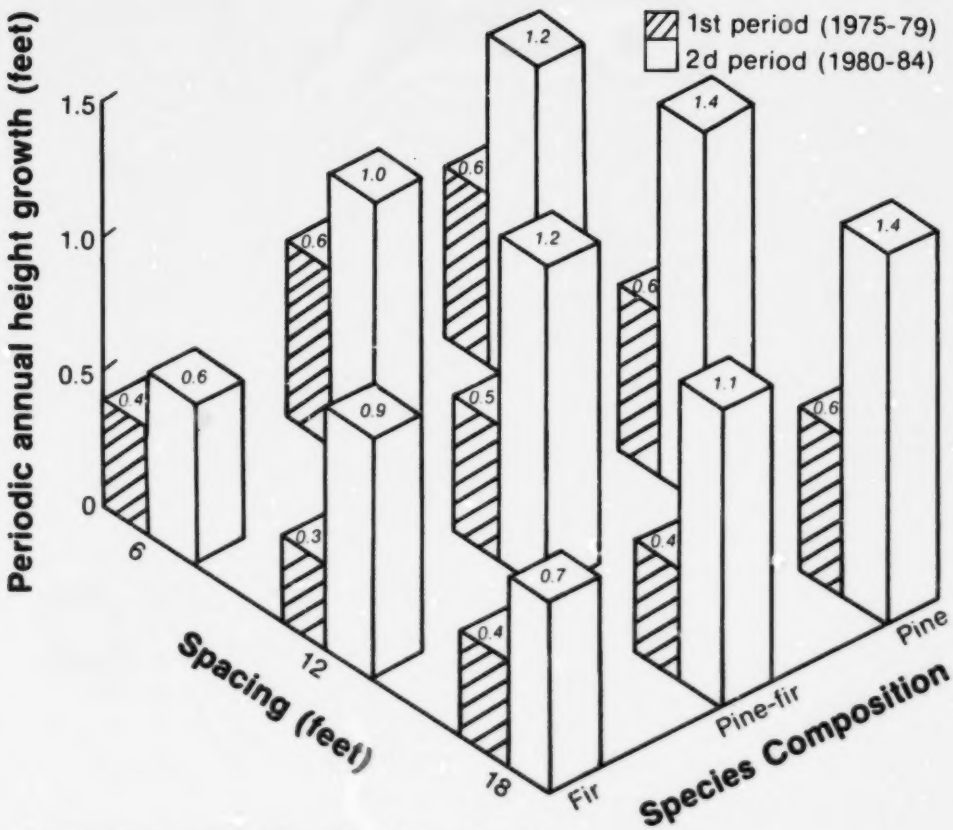

Figure 2.— Periodic annual height increment by species, spacing, and growth period, based on growth of all trees living through each 5-year period.

Basal Area and Volume Growth

During the first period, basal area and total cubic volume growth per acre was very small because most trees were less than 4.5 feet tall (table 2). During the second period, growth increased greatly (especially for pine) as more trees reached measurable size (ingrowth). For pure pine at the 6-foot spacing, for example, annual volume increment increased from 1.6 to 39.5 cubic feet per acre from the first to the second period. About 90 percent of volume increment during the second period was ingrowth.

Spacing and species combinations were significantly different ($P<0.01$) for both basal area and volume growth during the second period. Growth was significantly greater ($P<0.01$) at the 6-foot spacing but no significant differences existed between the 12- and 18-foot spacings. All three species combinations were significantly different ($P<0.01$) from each other: the greatest growth occurred in pure pine, intermediate growth in pine-fir, and least growth in pure fir (table 2). The spacing-species interaction was also significant ($P<0.01$) for both basal area and volume increment because of the much greater growth for pine and pine-fir at the 6-foot spacing as compared to fir (table 2).

Discussion

Ten years after establishment of this spacing study in a ponderosa pine-grand fir plantation, results already are typical of those generally found in initial spacing studies—greater diameter growth per tree at wider spacings and greater volume growth per acre at closer spacings. Because of the more rapid height growth of the pine, a stratified, two-storied stand is developing with pine the dominant species. Although pine is clearly dominant after 10 years, in the absence of freezing or animal damage, growth of grand fir was comparable to that of pine. For example, the most rapidly growing pine grew 9.9 feet in height during the 10-year study period compared to 9.7 feet for an undamaged fir.

It is apparent that grand fir plantations can be established with survival rates as good or better than those of ponderosa pine by using seedlings grown in large containers. The major disadvantage appears to be the greater susceptibility of grand fir to frost and animal damage in clearcuts, which results in reduced height and volume growth. The damage sustained by the fir during the first 5 years after planting resulted in a growth advantage for pine that is likely to be maintained for many years.

Metric Equivalents

1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 acre = 0.4047 hectare
1 square foot per acre = 0.2296 square meter per hectare
1 cubic foot per acre = 0.0700 cubic meter per hectare
1 tree per acre = 2.47 trees per hectare
1 quart = 0.9463 liter

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